TECHNICAL ASSESSMENT
OF
THE PROMAC BRUSH-DEMINER 48

A cooperative effort by the
Canadian Centre for Mine Action Technologies
and the Thailand Mine Action Centre

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Dated: MAY 2001-05-26

EXECUTIVE SUMMARY

This report presents the results of a technical assessment of the Brush-Deminer 48 (BDM48) conducted by the Canadian Center for Mine Action Technologies (CCMAT) and the Thailand Mine Action Centre (TMAC). The aim of the assessment was to determine if the BDM 48 is an appropriate tool for humanitarian demining.

Current demining practices rely on manual demining to locate and remove landmines. Mechanical systems offer a substantial increase in the rate of demining by removing underbrush therefore preparing the ground for locating mines, then detonating or neutralising antipersonnel land mines mechanically rather than destroying them by hand. To make available new and effective mechanical assistance equipment for demining CCMAT sponsored the design and testing of four proposed mechanical systems for demining. From that program it was determined that the BDM48, a proprietary equipment built by PROMAC, was operating well enough to progress to live trials. In November 2000 an agreement between the CCMAT and TMAC was signed to evaluate the BDM 48 in Thailand. The fieldwork was conducted in Sa Kaeo Province, Thailand from April to June 2001. Based on the Thailand fieldwork the BDM48 provides the following general capabilities:

- Safety and security for the operator by working from the cleared area and reaching into the mined area.
- Removes vegetation to make the ground available for using mine detectors or mine detecting dogs.
- Removes the tripwire threat.
- Removes or reduces the antipersonnel mine threat by neutralising mines by grinding or causing mines to detonate.

During the evaluation it was found that the BDM48 detonates or neutralises mines to a depth of 20 centimetres and can be operated in a manner that meets demining standards set out by the United Nations Mine Action Service. It was also found to be suitable for the environment and field conditions found in Thailand and is an appropriate equipment for humanitarian demining. It is therefore recommended that the Government of Canada contribute the BDM48 to TMAC to support the Thailand's Humanitarian Demining effort.

A secondary aim was to evaluate a new test and evaluation tool called the Mechanical Reproduction Mine (MRM). In these trials MRMs were found to act very closely to real mines and are considered appropriate tools for mechanical equipment testing and demining training.

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1.0 INTRODUCTION

In 1998 The Canadian Centre for Mine Action Technologies (CCMAT) established a program to test and evaluate (T&E) Mechanical Assistance Equipment (MAE) for Humanitarian Demining. This T&E program developed new test protocols and tools so that potential MAE systems could safely be evaluated in a controlled environment. The PROMAC BDM48 was one of the four equipments tested during that pilot phase.

In the MAE T&E program four standardized test environments were created in which inert but highly realistic MRMs were used to test candidate machines. The MRMs were designed to imitate an antipersonnel mine's physical characteristics and fuze action. Five different mines were selected to represent 5 of the most common types of anti-personnel mine fuze types, although only MRMs representing PMA 1, PMA2, PMA3 and PMN were used during tests in Canada. The ProMac BDM48 successfully neutralized (triggered the fuze or physically destroyed) 529 of 534 MRMs. At 99.1%, this was considered a superb result and preparations were made to expand testing of the BDM48 beyond the standardized test environments and MRMs and into real minefields with real mines. Before the BDM48 could be moved into a live environment the contractor, ProMac, selected the CASE 9040B as the prime mover and a protection package was built so that it could survive the blast environment. Blast trials were conducted to evaluate the effectiveness of the protection package. That trial series proved that the system performance was not affected after multiple 250 gram blasts to represent AP mine. Explosive testing against 81mm mortar, 105mm artillery shells and a 7.0 kilogram blasts demonstrated that the protection package provided very good protection to the operator and the machine.

In November 2000 the CCMAT visited the Thailand Mine Action Centre to determine if TMAC was able to support the T&E of the BDM 48. During that November 2000 liaison it was found that TMAC was already pursuing mechanical demining and had a progressive approach to combining mechanical tools with manual demining and mine detecting dogs. TMAC's operational focus as well as the available training and testing areas were ideal to conduct live trials of the BDM48. Moreover, the CCMAT assessment team understood Thailand's environment and felt that the level and type of threat present in that region was manageable for the trials. Finally, during the site visit it was found that while the test site was remote the necessary commercial services were present to support this class of equipment. Because of the positive environment that existed Thailand was selected as the preferred country in which to evaluate the BDM 48 and a letter of agreement between TMAC and CCMAT was signed.

Testing the BDM 48 in Thailand required administrative support to ensure timely customs clearances, access to Royal Thai Army controlled border areas in Sa Kaeo province, trained personnel to operate and supervise the equipment and run ranges. TMAC also provided and accounted for the live mines used during this evaluation. To provide an appropriate level of support for all tasks TMAC formed an assessment committee that was chaired by MGen Thamasak. The committee members were assigned from TMAC Headquarters, Burapha Field Force Headquarters, Humanitarian Demining Unit 1, and CCMAT. A final task of the committee was to hear the results of the evaluation and then based upon the test results decide if the BDM48 should remain in Thailand to be used by TMAC for day-to-day demining operations.

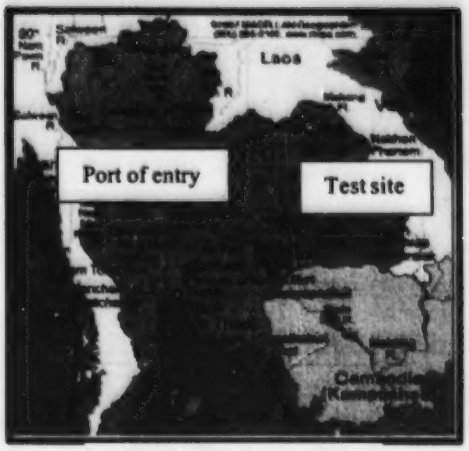


Figure 1: Test Site Location

The test site was co-located with TMAC's Humanitarian Mine Action Unit 1 (HMAU1) in Sa Kaeo province. The evaluation would occur in two separate areas at Ban Nong Ya Kaeo: one area for training with MRM and testing with unfuzed M14 mines, and a second area located in a cleared area of a minefield where live M14 tests could be conducted. The live test were done in a minefield because HMAU1 already had control points set up with radio communications to prevent people from entering the area, and the area was far enough away from the nearest village to allow for safety when a mine blast occurred.

The CCMAT assessment team was organised to provide operational and technical control over the evaluation. The PROMAC assessment team was organised to provide administrative, training and mechanical support to the evaluation. PROMAC provided personnel with the skill sets to train, maintain, or modify the BDM 48 system in the field. PROMAC's approach greatly added to the success of the evaluation. TMAC provided area control through the HMAU1 plans officer.

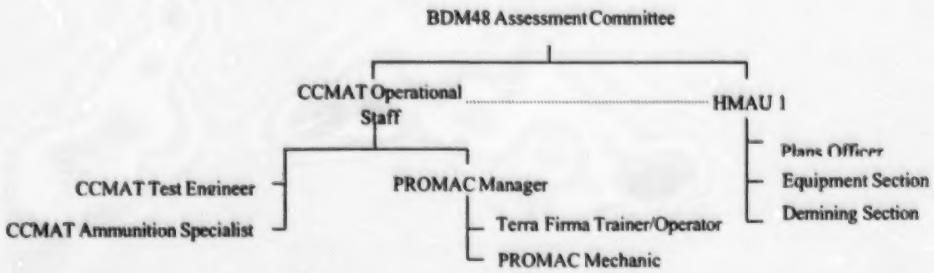


Figure 2: Organization of BDM48 Assessment team

2.0 AIM

The aim of this evaluation was to determine if the PROMAC Brush-Deminer is an appropriate tool for humanitarian demining.

Secondary goals were:

- To confirm the performance of the CCMAT Mechanical Reproduction Mine.

- To provide positive feed back to PROMAC so that they could improve the BDM 48 system performance.

- To determine if the PROMAC BDM 48 should be used by the Thailand Mine Action Centre for demining operations.

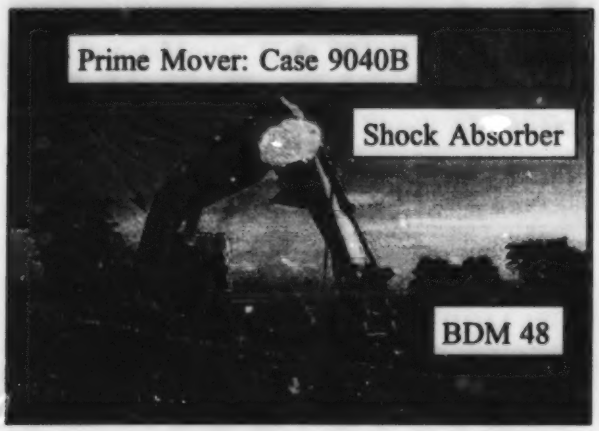


Figure 3: BDM 48 System

3.0 TESTING METHODOLOGY

In keeping with the intent of the CCMAT MAE program, testing of the BDM48 was conducted in the following logical step-by-step process.

- **Operator training**. Before testing could begin TMAC operators had to be trained to use the prime mover and apply the BDM48 attachment. The CCMAT assessment team included an operator/trainer provided by Terra Firma from Edmonton Alberta,Mr. S. Schmidt. Mr Schmidt was the same operator who used the BDM48 system in the DRES trials, which provided excellent continuity between the Canadian tests and Thailand. TMAC provided two excavator operators as per the TMAC/CCMAT letter of agreement. Both operators were trained combat engineers who understood

humanitarian demining. One operator had formal heavy equipment training, while the second operator had only practical experience. Both operators were well versed with the prime mover and the controls before arriving on site. This greatly sped up the training process allowing the assessment team to focus on training the operators to use the BDM48 rather than training the operators to use the entire machine. A total of 29.5 hours of theory and practical training was done. See Annex A for more detail.

- **MRM testing.** Using MRMs permitted the assessment team and operators to safely develop drills that would be applied to all test scenarios. It also enabled the operators to use the machine against mine like targets while working in a benign environment. MRM testing also allowed the assessment team to compare the performance of the MRM with the test results in Canada and directly with the M14 mine.

- **Unfuzed M14 testing.** Testing with unfuzed mines allowed the assessment team to predict what would happen should the M14 mine not detonate during the tests. Using unfuzed mines practised the assessment team's test procedure in advance of live testing. Finally the M14 mines were built in1956, unfuzed testing allowed the team to test the M14's ability to function as designed.

- **Live M14 testing**. Fuzed M14 mines were placed in specifically prepared areas of a minefield. Placing the mines just beyond the edge of the prepared "safe" areas, provided the realism needed for this technical evaluation. In earlier testing at Defence Research Establishment Suffield it was found that the pressure required to function M14 mines is substantially lower than the advertised 20 to thirty five pounds. This presented a safety hazard to the assessment team while burying mines during the live trials that was mitigated by not covering deeply buried mines with soil during testing.

- **Vegetation Clearance.** To provide a general debrushing rates, and to demonstrate the machines ability to work in the challenging jungle foliage and root structure.

4.0 MECHANICAL REPRODUCTION MINE TEST SUMMARY

While the result that captures everyone's interest is the performance of the system against live mines, it is useful to examine the results of the mechanical reproduction mines and the unfuzed M14 mines. A total of 36 trials were conducted using Mechanical Reproduction Mines. The trials, described in detail in Annex B-1 and B-2, took place in low grass, heavy grass, brush, wet and somewhat drier soil, along the sides of termite hills, and in the slope transition zones along the edge of the termite hills. MRMs were placed at depths ranging from 5-20cm.

Of the 36 MRMs used in the trials, 2 were found to be intact and functional ("live"). The first missed MRM was the first ever attempt by one of the operators and so

should be discounted due to operator inexperience. In the second case the MRM showed no signs of contact by the machine, but the MRM had been moved from its original location into the berm of loose, processed soil. While it cannot be stated with certainty, it is suspected that the reason for this type of result is slow drum speed. If the operator allows the BDM48 drum to stall or rotate too slowly, the teeth may simply push the MRM (or mine) from one place to another. To help the operators avoid slowing the drum rotation by pushing the BDM48 into the ground too fast, PROMAC installed a gauge in the cab that helped the operators monitor the hydraulic pressure in the BDM48. By observing the gauge the operators could maintain a high drum speed thus ensuring the BDM 48 teeth could contact the mine with sufficient energy to break it. In many MRM tests is was not possible to tell whether the MRM fuze had functioned, and if so, whether it had functioned before or after the MRM had been broken apart. For the purposes of these tests either a broken (neutralised) MRM or a detonated MRM is considered a good result.

5.0 UNFUZED M14 TEST RESULTS SUMMARY

The details of the unfuzed M14 mine testing are included in Annex C. M14 mines have a Belleville spring that drives a firing pin into a detonator. To allow the Belleville spring to function normally without detonation the dust plug was removed and trimmed to the length of the live detonator. The dust plug was then reinserted into the mine to act as a surrogate fuze. By burying the unfuzed M14 mine in varying scenarios and applying the BDM 48 the assessment team could monitor the location and status of the spring, explosive filler, and surrogate detonator after each test. This proved to be an excellent method to evaluate how the BDM48 interacts with a mine that may not have fired, and to prepare the evaluation team for live trials. For the purposes of this evaluation the results of each test were classified as follows:

Figure 4: M14 Shipping Plug Modification

Detonated	The fuze functions as designed causing the mine to detonate (high order)
Neutralized	The mine cannot detonate because - the fuze, detonator, and filler have been separated - the firing system has been disrupted
[illegible]ve	The Belleville spring, detonator, and explosive filler are intact, and the mine can function as designed.

Table 1: Evaluation Terminology

Initial plans called for the unfuzed M14 trials to be conducted in a cleared area of an adjacent minefield. During MRM trials it was noted that searching the berms for mine pieces following soil processing by the BDM48 could be very time consuming. The

assessment team also observed that TMAC had buried unfuzed mine bodies in the area for training purposes. Discussions with TMAC personnel concluded that the unfuzed M14 trials could be conducted in the same low risk training area used for the MRM trials. The benefits of this decision were threefold. First, being a low risk area rather than a minefield, searching for pieces could be conducted by several people at a time thus hastening the test process. Second, trials could be conducted with much greater speed without the need for removing people to a distant safe area between trials. Finally the limited number of "brush" sites available in the minefield could be reserved for the live trials exclusively.

A total of 25 unfuzed M14 mines were placed at depths of burial from 0 to 200mm, with three of the trials being conducted at depths beyond 200mm. These trials were done intentionally at depths beyond the machine's stated depth capability of 20 centimetres to test the limits of the machine. One mine deeply buried mines was neutralised with evidence that suggests no detonation would have occurred while the other two remined intact.

Of the remaining 22 unfuzed M14 mines, 3 were found intact but with their fuzes functioned, thus indicating detonations. One other mine was found neutralized (broken up and with the fuze and detonator removed from the main charge), but with the spring in the unfired position. It is impossible to make definitive conclusions about whether the mine would have been broken apart before the fuze functioned, or whether it would have detonated first but either result is acceptable. The unfuzed trials did confirm the BDM 48's operating depth of 20 centimetres as required by UN Standards.

In addition to varying depths of burial and soil/environment, several mines were intentionally buried rolled onto their sides. Some were buried with the pressure plates facing the machine teeth, and some with the pressure plates facing the operator. The purpose of this test was to see if soil deformation alone would function the mine. Test results did not vary from normally employed mines in that mines buried within the operating depth of the machine were neutralised/detonated, mines buried deeper than 20 centimetres were left intact.

6.0 LIVE M14 TEST RESULTS SUMMARY

The details of the live M14 testing are presented in Annex D, the full test procedure is explained in Annex E. In all 35 live M14 mine trials were conducted, of which 33 mines detonated.

Figure 5: Live Test Area

In preparation for live M14 mine testing, TMAC prepared a section of road until it was deemed to be a low risk area. Off each side of this road 3-meter stub lanes spaced four to 5-metres apart were prepared, first by debrushing with the Tempest flail, and then by either manual demining teams or demining dog teams, or

both. Some lanes were in clear ground with little vegetation, or low grassy cover, while others were in brush conditions ranging from waist high weeds to small trees 2-3 metres tall or more.

For safety, one M14 was buried at a time. Following the BDM48's processing the area was checked to ensure there were no partial detonations or pieces of other mines. At this point the location for the next mine was prepared. For safety reasons, the live M14 mines were not covered with soil after being placed. They were, securely seated at the bottom of their holes, and soil was packed around the sides of the mine body. While this approach was taken to avoid the risk of setting of a mine while packing soil on top of it, a side effect was that it made it more difficult for the machine to detonate the mines since there was no "plug" of soil which could be pressed down onto the fuze.

Live M14 mines were buried in clear or low-grass conditions and in brush conditions at depths of burial ranging from 0 centimetres (flush buried) to 20 centimetres. Generally soil conditions were dry although a few tests were conducted in soil that was saturated with water. In addition to the variations in soil/terrain/environment and depth of burial, two mines were rolled onto their sides, one with the pressure plate facing the machine teeth, and one facing the operator.

All but two of the live M14 mines resulted in detonations. One mine that did not detonate was thoroughly neutralised with the belleville spring removed and destroyed, and the explosive filler removed and demolished. The detonator was retrieved and showed no signs of contact from the firing pin even though the spring was triggered. Examining the fragments suggests that one of the BDM48 teeth likely caught the side of the mine body and peeled the top (fuze) section from the bottom section. This or subsequent impacts broke the mine apart separating the fuze mechanism and shattering the explosive filler.

The second undetonated M14 was found unfired, and intact in the berm. This mine had been laid at 100mm depth, and rolled on its side, presenting the pressure plate toward the machine operator. In this position the BDM48 teeth are aimed at the side of the mine rather than at the pressure plate. The mine may have rolled through the BDM48 because of low drum speed or may have been caught between teeth. In any case the subsequent scraping action was responsible for moving the mine from its initial location and into the berm. TMAC deminers demined the berm and removed the intact mine. This result illustrates the need to follow the proper machine SOP and to include clearing the berm after the BDM48 is used.

7.0 CORRELATION OF RESULTS

Normally users focus on the machine's performance against live mines. But it is useful to determine if the MRM and unfuzed mine trials were of any value. If it can be shown that using safer unfuzed mines or even inert MRM test pieces provide the same or even similar results to the live trials, then machine performance might be estimated or predicted based on these types of trials before committing to live trials.

Working from the live trials backward, it is interesting to note that almost all of the live mines detonated, and of the two that did not, one was thoroughly neutralized. This corresponds closely with the results of the unfuzed mines. Ignoring those mines buried beyond the machine's operating depth of 20 centimetres, all but one of the unfuzed mines were neutralized or detonated, while one mine was neutralized rather than being detonated. Considering that detonated mines and neutralized mines are both satisfactory results, the unfuzed trials seem to provide a valuable evaluation tool.

Did the MRM trials provide any useful data that correlates with the mine trials, either live or unfuzed? If the results of the trials are simply normalized by calculating the percentage which were detonated, neutralized or live, we find a very good correlation between the MRMs and the M14 mines.

Target Type	Live	Neutralized	Detonated	"Dead" (Neutralized or Detonated)
Type 72A MRM	6	86	8	94
Unfuzed M14	0	86	14	100
Live M14	3	3	94	97

Table 2: Percentage Comparisons

Table 2 illustrates that the BDM48's performance against Type 72A MRMs is analogous to its performance against M14 mines. The reasons for this is that the machine breaks up virtually all of the mines and those that are not broken normally detonate. For a machine like the BDM48 it is constructive to examine "how" the mines and MRMs are normally broken up. Are the MRM fragments similar to the M14 fragments? For this we relied heavily on the unfuzed M14 data. Annex F shows a sampling of MRM fragments and M14 fragments. By comparing the broken unfuzed M14 mines with the broken MRM mines it can be seen that there is a very good correlation between the two even considering that the MRM is not an M14 model. While there are structural and materials differences between the MRMs and their real counterparts, the MRMs appear to be a good substitute target for the real mines, at least in the case of the Type 72A MRM and the M14 mine. Therefore we conclude that for machines like the BDM48, MRMs perform close enough to real mines and are a useful tool for T&E as well as for training.

Figure 6: M14/MRM Correlation

8.0 DEBRUSHING

The purpose of debrushing is to expose the ground in preparation for locating mines using hand held metal detectors or mine detecting dogs. Debrushing can take up to seventy percent of the deminers time. Consequently the debrushing capability alone offered by the BDM48 provides a significant increase in the overall rate of demining that deminers can achieve. In Thailand the minefields have been overgrown by underbrush and bamboo. Bamboo, especially, slows or prevents demining to the point where debrushing equipment is an operational necessity. The rate of debrushing can vary widely and depends on many variables. However, in the five trails held in Thailand, debrushing rates in thick underbrush and bamboo from 4 to 8 square metres per minute were achieved. Annex G describes the five timed debrushing trials that were undertaken.

Figure 7: Debrushing Bamboo

When using mechanical equipment for demining the machine must not only deal with vegetation above the ground, but it has to work through the root mass in the ground. In dry hard-baked ground root mass acts like reinforcing bar in concrete that obstructs manual demining. Bamboo has a large interwoven root mass that, in wet conditions, is elastic and is very difficult to work through. During these trials the BDM48 was used in both dry and wet conditions. Tests confirmed that the constant pressure of the BDM48 is enough to work through root mass up to 8 centimetres in diameter and still detonate or neutralise the mine.

Figure 8: Root Structure Successfully Removed

9.0 SYSTEM LIMITATIONS

Despite its impressive performance in the original MAE T&E trials and the subsequent results in Thailand, the BDM48 does have limitations. The assessment team observed the following limitations of the system:

- The successful application of the ProMac BDM48 is highly dependent on operator skill. Careless use or inattention to the SOP may cause the machine to miss mines.

- It is critical that the rotational speed of the BDM48 drum be maintained when grinding a suspected mine location so that the BDM 48 contacts the mine with sufficient energy to break the mine into pieces. Failing to maintain rotational

speed could result in mines being pushed rather than being detonated or neutralized.

- The live trials in Thailand indicated that a very high percentage of M14 mines detonated or were neutralized. Using the BDM 48 in other environments or against other mine types may offer different results. Initially, as the machine experience grows, MACs should test the machine against their threat mines and in their environment to ensure the BDM 48 suits their needs.

- Even with a skilled operator there is the possibility that mines buried at the limit of the machine (20 centimetres) may be missed or incompletely destroyed. The operation of the machine must be followed up by other means to check that the target area is clear of suspected mine targets.

- Any operation, but especially operation in saturated soil, can result in soil being packed under the head of the machine. This results in mud and soil being packed around the bearings that supports the BDM48 drum. The operators should remove all soil from around the bearings to prevent the mud from slowing the drum rotational speed. This is also a preventive maintenance measure. The trials demonstrated that mine fragments may become embedded in soil packed in the BDM48 itself. The operators should remove packed soil at the end of the day and watch for mine fragments that may need to be destroyed.

- In cases where the mine has been rolled over on its side and deeply buried, the machine may neutralize rather than detonate the mine. This was especially noted when the pressure plate of the mine was oriented toward the machine operator; in this position the BDM48 teeth are aimed at the side of the mine and the downward pressure of the machine is also aimed at the side of the mine. Therefore the ground soil forming the berm as well as the bottom of the ground spot will have to be cleared by deminers after the machine is used to check for and remove mine parts.

- As the machine is employed in a spot-digging operation rather than a continuous in-ground grind, there is the opportunity for ridges to be formed on the bottom of the processed area. The standard operating procedures adopted must ensure that these ridges are also ground off.

10.0 TMAC STANDARD OPERATING PROCEDURES SUMMARY

The Thailand Mine Action Centre (TMAC) considers mechanical assistance to demining as an essential element of its humanitarian demining program. The reason for using mechanical systems is to accelerate manual demining or demining with dogs. Therefore the BDM48 will not be used as a stand-alone system. Annex H provides draft SOPs for using the BDM 48 in support of humanitarian demining. These SOPs are specific to TMAC and will be amended as experience is gained with operating the BMD48. The BDM48 provides the following general capabilities:

- Safety and security for the operator by working from the cleared area and reaching into the mined area.

- Removes vegetation to make the ground available for using mine detectors or mine detecting dogs.

- Removes the tripwire threat.

- Removes or reduces the mine threat by neutralizing mines by grinding or causing mines to detonate.

- Follows the contours of the ground.

- Works in and around obstacles to demining including termite hills, slope up to 45 degrees.

- Applies the BDM48 tool head above and below the level of the machine

- Works through root structure, and rough ground.

- Works in adverse weather conditions such as rain and saturated soil.

- Provides the demining unit with a finesse tool that can work around specific locations without destroying infrastructure and vegetation.

The BDM 48 system will fit into TMAC's current command and control structure and integrate into TMAC's process of mine clearing which includes all levels of survey, mined area marking, demining, and post demining action. The system will be employed as part of a mechanical demining platoon. The mechanical demining platoon will be controlled centrally by TMAC's Humanitarian Mine Action Units (HMAU) plans staff who selects and controls the locations and priorities of work where the platoon will work.

Role 1: Brush clearing and demining.

Role 2: Area reduction.

Role 3: Quality assurance.

11.0 CONCLUSIONS

The MRM is an appropriate tool that specialist teams or demining units can use in the field to safely test and evaluate mechanical tools for demining. It also offers a realistic tool for manual demining training.

As a result of testing, the BDM48 system was modified on site so that it better suited the operational task of demining. Modifications included a gauge that allows the operator to monitor the hydraulic pressure in the BDM 48 working head, and a scraping blade to allow the operator to remove the spoil from the ground location and see the bottom of the excavation. With those modifications, the BDM 48 system was ideally suited to the demining conditions found in Thailand. See annex I for a full description of the system modifications employed.

The existing shock damping device works well when loaded vertically during a mine blast. However during this evaluation it was found that the device is too flexible for the operators to control the BDM 48 during the scraping process. The scraping process also creates lateral loads that the damping system was not designed to withstand and could become a maintenance problem over time. It is recommended that the shock damping include lateral stiffening to that the shock absorbing qualities of the system are not degraded because of continual lateral loading of the system.

12.0 RECOMMENDATIONS

During the evaluation it was found that the BDM48 detonated or neutralized all mines to a depth of 20 centimetres and can be operated in a manner that meets demining standards set out by the United Nations Mine Action Service. It was also found to be suitable for the environment and field conditions found in Thailand. It is therefore recommended that the Government of Canada contribute the BDM48 to TMAC to support the Thailand's Humanitarian Demining effort. TMAC's observations are included in this report at annex J.

Should the Department of Foreign Affairs and International Trade fund a project to utilise the BDM48 in Thailand, it is recommended that operational statistics be collected and returned to CCMAT as experience with the system increases.

The CASE 9040B contains sophisticated computers and controls that the operators and supervisors are not familiar with. It is highly recommended that the operators and supervisors be given formal training on the use and maintenance of the prime mover by CASE representatives working in Thailand before demining with the BDM48 starts.

BDM48 TRAINING SUMMARY

1. TMAC provided two excavator operators as per the TMAC/CCMAT letter of agreement. Both operators were trained combat engineers, one operator had formal heavy equipment training, while the second operator had practical experience only. Both operators were well versed with the prime mover and the controls before arriving on site. This greatly sped up the training process as the assessment team could focus on training the operators to use the BDM48 only rather than training the operators to use the entire machine.

2. Mr. Stu Schmidt from Terrafirma Edmonton trained the two TMAC operators. Mr Schmidt is a heavy equipment supervisor and trainer who specializes in training operators to use excavator equipment modified for non-excavating roles. Mr Schmidt comments that the training was too condensed and could have been at least a week longer to provide the operators the opportunity to become more efficient with the equipment. While it was clear that the TMAC operators knew how to run the equipment they lacked experience and fine control of the excavator arm. The success of using the BDM48 depends more on the operator's proficiency than on the machine, properly trained operators are essential. Therefore it is recommended that future projects start with more intensive training to include basic digging using a standard bucket so the operators can learn to move the BDM48 and prime mover with finesse before progressing to using the BDM48.

3. PROMAC observes that when providing new operators with modified equipment, like the Case Excavator with the BDM 48, the highest incidence of machine damage occurs within the first two days of use. Damage occurs because the operator is not familiar with relationship between the hydraulic system and the new cutting tool he is using. The operator cannot do the work the way he would normally perceive it, he then uses the machine too aggressively and damages the machine. It should also be noted that machine stability also changes when heavy modifications are made such as armouring the cab. When modifying the Case excavator for using the BDM48 Terrafirma selected a shorter boom so that the operators could not overextend or tip the machine.

4. The following training items were covered:

ITEM	STUDENT	TOPIC	TIME
1	Translator	Work out English/Thai machine terminology a. Theory b. Practical	 3 Hours 1 Hour
2	Translator	Work out English/Thai mine terminology It should be noted that the interpreter spent over 10 hours of personal reading to study and become familiar with the terminology and field engineering terms used by TMAC and the assessment team.	2 Hours
3	TMAC Operator	Machine Familiarisation: instruments, controls, machine first and last parade.	1.5 Hours
4	TMAC Operator	Basic arm movement, machine speeds, machine feel. a. Operator Practical Exercises b. Instructor Demonstration c. Cutting Bites d. Cutting Spots e. First MRM (three for each operator) f. Brush Cutting g. Transition zones	 3 Hours 0.5 Hours 4 Hours 6 Hours 3 Hours 2 Hours 1 Hour
5	Supervisor	Safety Checks Maintenance Monitoring Templates	Concurrent with Operator Training
6	TMAC Operator	Tooth Hardening a. Welding Practice b. Demonstration	 2 Hours 0.5 Hours
7.	Total Training Hours		29.5 Hours

5. Tooth Hardening. Tooth hardening is a technique of adding beads of weld to the tooth in order to minimise tooth wear during use; it prolongs the life of the BDM48. PROMAC staff conducted a tooth hardening demonstration with TMAC's operators then gave the operators welding practice. During three weeks of operation tooth hardening was required only once. Additionally, as the machine moved into the live trials the carbide tip of two 'bullet' teeth were chipped off. During the test these teeth were replaced, but in normal practice the tooth could have been built up with weld rather than replacing it.

6. For more information about the system design contact:

PROMAC Mauracturing Ltd
2940 Jacob Road
Duncan B.C. Canada
V9L 6W4

Terra Firma
16641-114 Avenue
Edmonton, Alberta
Canada. T5M 3P9

TRIAL SETUP AND GENERAL INFORMATION

1. A training area immediately behind the HMAU1 headquarters was selected for testing of the BDM48 with the MRMs. This area provided a good range of environments for testing; low grass, heavy grass, brush, bamboo stands and other trees, Termite hills, slope, wet, saturated soil, and hard baked soil were all present to complement the very environmental conditions encountered in the original CCMAT MAE tests in Canada.

2. In each series of trials (MRM, unfuzed M14), locations were selected for individual targets. To bury the mine or MRM, a small hole was excavated to the required depth. The "depth of burial" refers to the distance from the top surface of the mine to the surrounding ground surface, and not to the bottom of the hole. The unfuzed M14 or MRM was then seated securely in the hole and soil was packed around the sides of the mine. In the MRM and unfuzed M14 trials soil was then carefully put back in the hole to cover the target.

3. Having been buried or placed in their holes, reference marks were painted on the ground to mark the location of the buried mine. The mines were marked in this manner for several reasons. First, these tests were intended to evaluate the machine's performance and not the operator. Making the operator guess at the location might skew the results. The second reason for marking the target is that during the demining process, deminers using mine detectors or mine detecting dogs use plastic triangles to pinpoint a potential mined location. It is anticipated therefore when integrating the BDM48 into normal operations the location TMAC would want the BDM48 operator to process would be marked. Lastly, mine locations are marked during testing to provide the starting point from which the search for the mine or its components would start should a mine fail to detonate.

4. After the mine or MRM had been placed and marked the machine was moved into place. In some instances mine tape was used to simulate the edge of minefields. This gave the operators some practice with positioning the machine correctly without crossing the boundary between cleared and uncleared areas.

5. Immediately prior to starting machine operation all personnel including the equipment section supervisor were moved to a designated observation point. In many cases the observation point was located such that the supervisor could not see the target location well and could not provide detailed guidance to the operator. Again, this was to ensure that the team would be able to function in the real minefield tests where the supervisor would have to be remote from the machine.

Typical "Low Grass" Test Area

Typical "Heavy Grass" Test Area

Typical "Brush" Test Area

Typical "Wet" Soil

Typical Termite Hill Test Area

Typical "Wet" Soil

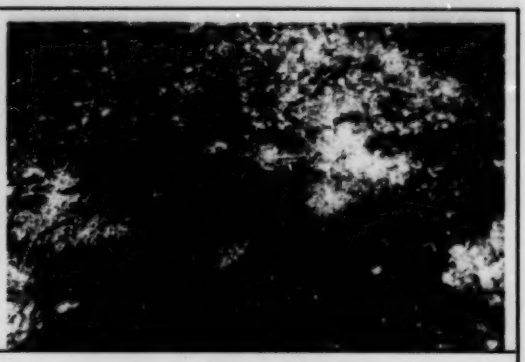
Typical "Dry" Soil

Typical "Dry" Soil

Typical Burial Process
Mine Placement

Typical Burial Process
Soil Cover (MRM And Unfuzed M14)

Typical Burial Process
Painting Target Location



Typical Burial Process
Painted Registration Marks

Mine Tape Marking Imaginary Edge Of Minefield

Blank

CCMAT/TMAC/PROMAC BDM48 MRM Test Data

Annex B-2 to
BDM48 Test Thailand
Dated: May 01

	Setup						Results				
Trial #	MRM #	MRM Type	DOB (mm)	Distance (m)	Operator	Environment	Time (min)	Functional Mine	Neutralized Mine	Destroyed By Detonation	
2001-05-18-01	2920608	T72A	100		Pop	Low grass			X	X	. Practice . Spring inverted . Fuze missing . Detonator & main charge may still be together but fuze missing
2001-05-19-01	2851794	T72A	50	5.8	Pop	Low grass			X		. Practice . Broken apart . Spring not inverted . Fuze removed from main charge
2001-05-19-02	2852245	PMA2	60	5.8	Pop	Low grass			X		. Practice . Broken apart . Plunger missing
2001-05-19-03	3047034	T72A	130	4.9	Tea	Low grass		X			. Practice . Rubber cap removed, otherwise intact . Live, functional . Top edge of mine scuffed
2001-05-19-04	3075976	T72A	130	4.7	Tea	Low grass				X	. Practice . Rubber cap removed, otherwise intact . Fuze functioned
2001-05-19-05	3055680	PMA2	160	4.2	Tea	Low grass			X		. Practice . Broken apart . Detonator removed from main charge . Plunger removed
2001-05-19-06	2869144	T72A	150	4.2	Tea	Low grass			X		. Mine broken, coil live . Spring not inverted . Fuze separated from main charge . HE removed from container
2001-05-19-09	2923069	PMA2	90	5	Pop	Low grass				X	. Intact, no plunger . Fuze functioned
2001-05-19-08	14546946	PMA2	50	5.3	Pop	Low grass	11.5		X		. Broken apart . Fuze damaged, plunger removed . Fuze separated from main charge.
2001-05-19-07	3045364	PMA2	130	5.5	Tea	Low grass	6		X		. Broken apart . Fuze separated from main charge . Heavy fuze damage likely, although unconfirmed
2001-05-19-10	3047049	PMA2	55	6.3	Pop	Low grass	8.5		X		. Intact, live, plunger removed
2001-05-20-01	2842346	PMA2	120	4.9	Pop	Low grass	5		X		. Broken apart . Fuze removed from main charge
2001-05-20-02	3030502	PMA2	100	5.7	Tea	Low grass	8		X		. Broken apart . Fuze removed from main charge
2001-05-20-03	2923441	T72A	110	5.0	Pop	Low grass, soil drier than most other areas			X	X	. Broken apart . Fuze removed from main charge . Fuze functioned
2001-05-20-04	2858667	T72A	120	5.1	Tea	Low grass			X		. Broken apart . Fuze removed from main charge
2001-05-20-05	2857640	T72A	150	7.4	Pop	Low grass	5		X		. Broken apart . Fuze removed from main charge

2001-05-20-06	2853716	T72A	130	6.2	Tea	Low grass	8	X			. Top and bottom bodies separated in person's hand after recovery . Intact, live, untouched by machine . Moved into spoil
2001-05-20-07	2842321	T72A	120	5.9	Pop	Low grass, drier soil			X		. Broken apart . Fuze removed from main charge . Spring not inverted
2001-05-20-08	2924235	T72A	100	6.4	Tea	Heavy grass, very damp soil			X		. Broken apart . Fuze removed from main charge
2001-05-20-09	2856478	PMA2	90	6.7	Pop	Heavy grass			X		. Broken apart . Fuze removed from main charge
2001-05-20-10	2852922	T72A	100	5.8	Tea	Heavy grass			X		. Broken apart . Fuze removed from main charge . Spring not inverted, coil live
2001-05-20-11	2854212	T72A	120	6.7	Pop	Heavy grass			X	X	. Broken apart . Fuze removed from main charge . Spring inverted (fuze functioned)
2001-05-20-12	2840780	T72A	120	6.3	Tea	Heavy grass			X	X	. Broken apart . Fuze removed from main charge . Spring not inverted but coil punched
2001-05-20-13	2858939	T72A	130	5.3	Pop	Heavy grass	5		X		. Broken apart . Fuze removed from main charge
2001-05-20-14	3046690	PMA2	140	6.6	Tea	Heavy grass			X		. Broken apart . Fuze removed from main charge
2001-05-20-15	2867554	T72A	150	5.9	Pop	Heavy grass				X	. Intact, except cap removed . Fuze functioned
2001-05-20-16	2853692	PMA2	100	6.2	Pop	Brush, termite hill, transition zone			X		. Intact, live, plunger removed, otherwise untouched
2001-05-20-17	3046718	PMA2	90	5	Tea	Brush, termite hill, transition zone			X		. Broken apart . Fuze removed from main charge
2001-05-21-01	2858160	T72A	90	6	Pop	Termite hill, bamboo roots, drier soil			X		. Broken apart . Fuze removed from main charge
2001-05-21-02	2921301	T72A	70	5.9	Tea	Termite hill, brush cover, drier soil			X		. Broken apart . Fuze removed from main charge . Spring not inverted
2001-05-21-03	3058596	T72A	60	5.2	Pop	Termite hill, brush cover, shrub roots, drier soil			X		. Broken apart . Fuze removed from main charge
2001-05-21-04	2934774	T72A	100	6.2	Tea	Termite hill, brush cover, beside small mound, drier soil			X		. Broken apart . Fuze removed from main charge . Spring not inverted
2001-05-21-05	3046097	T72A	150	5.8	Pop	Termite hill, brush cover, behind tree roots, drier soil			X		. Broken apart . Fuze removed from main charge
2001-05-21-06	2869152	T72A	200	5.9	Tea	Termite hill, side slope			X		. Rubber cap and spring only found . Thus, fuze removed from main charge . Further grinding only turned up fragments from top part of MRM
2001-05-21-07	2854853	T72A	100	5.6	Pop	Termite hill, side slope			X		. Broken apart . Fuze removed from main charge . Spring not inverted . Main charge "HE" filler removed from MRM body

2001-05-21-08	2838739	T72A	120	5.3	Tea	Termite hill, side slope			X		. Broken apart . Fuze removed from main charge . Considerable scatter of pieces since BDM48 head was in the air when the drum contacted the mine on the side slope. Where possible, grind from bottom upward to allow some spoil to build up and catch the pieces.

Definitions

1 Functional Mine
The mine is intact, substantially undamaged, and capable of functioning as designed.
2 Neutralized
The mine can no longer function as designed as the means of initiation have been removed.
3 Destroyed by Detonation
The mine has been detonated.
4 Dry vs Wet Soil
None of the soil was really dry. See the photos for comparative dry/wet evaluation.
5 DOB
Depth of Burial as measured from ground surface to top of mine. If mine has been rolled on its side, DOB is measured to the top-most part of the mine.

Notes

1 Digging pattern used in trials allows a small pile of spoil to develop to help catch broken M14 pieces for analysis. May not be needed in demining operations but for testing it keeps the drill consistent, avoids changes in procedures that MIGHT compromise results, and minimizes scatter of pieces. With successfully detonated mines it does not matter, but it might matter if a mine does not detonate.

Summary

36 MRM trials
Low grass, heavy grass and light brush environments
Very damp to reasonably dry soil conditions
Flat ground, side slopes, transition zones
DOB: 5cm to 20cm
3 Detonated (definite) MRMs
31 Neutralized or detonated (uncertain) MRMs
2 Functional, live MRMs

UNFUZED M14 TEST DATA

1. Initial plans called for the unfuzed M14 trials to be conducted in a cleared area of a TMAC minefield. During MRM trials it was noted that searching the berms for mine pieces following soil processing by the BDM48 could be very time consuming. It was also observed that TMAC had already buried unfuzed mine bodies in the test area for training purposes. In discussions with TMAC deputy commander the assessment team was given permission to conduct the unfuzed M14 trials could be conducted in the same low risk training area used for the MRM trials. The benefits of this decision were threefold. First, being a low risk area rather than a minefield, searching for pieces could be conducted by several people at a time without the risk of finding pieces of mines other than our test pieces. Second, trials could be conducted with much greater speed without the need for removing people to a distant safe area between trials. Third, this meant that the limited number of "brush" sites available in the real minefield could be reserved for the live trials exclusively.

2. Twenty-five separate locations in the training area were chosen that included: low grass, heavy thigh-high grass, and light under brush, bamboo, and slope. Unfuzed M14 mines were buried at depths from 0 to 200mm, with three of the trials being conducted at depths beyond 200mm. These trials were done intentionally at depths beyond the machine's stated depth capability to establish the limits of the machine.

3. In addition to varying depths of burial and soil/environment, several mines were intentionally buried on their sides. Some were buried with the pressure plates facing the machine teeth, and some with the pressure plates facing the operator.

4. Of the three mines buried below 200mm, two were missed and left intact and functional by the machine. The third was actually neutralized but in this case the operator had been signalled that the mine was very deeply buried; in an effort ensure a neutralization, the normal soil processing pattern may not have been strictly followed. The point is still made however that the machine does not reliably neutralize mines below 200mm DOB.

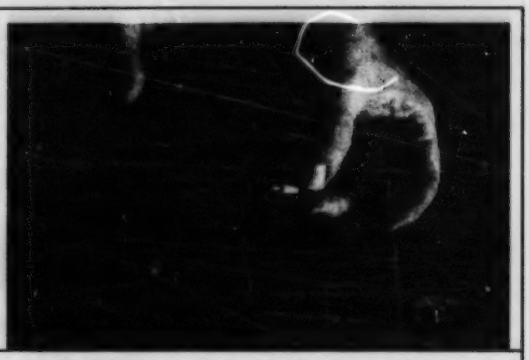
5. Of the remaining 22 unfuzed M14 mines, 3 were found intact but with their fuzes functioned, thus indicating detonations. One other mine was found neutralized (broken up and with the fuze and detonator removed from the main charge), but with the spring in its original, unfired position. This suggests a mine that was neutralized but <u>not</u> detonated. Notwithstanding this observation, it is certainly possible that the fuze might have functioned and that subsequent machine operation could have taken the inverted spring

and popped it back to its original position. Without a live mine this could be determined with certainty.

6. This leaves 18 unfuzed mines which were found neutralized and in a condition which might also suggest detonation (an inverted spring), but in which it is very difficult to state whether a detonation would have preceded neutralization or vice-versa. Either destruction by detonation or destruction by neutralization is considered a satisfactory result.

7. Regarding the mines rolled onto their sides, only one failed to be neutralized/detonated. This was one of those mines intentionally buried below the 200mm working depth of the machine. All others were either neutralized or detonated.

M14 Mines Painted To Allow Visual Identification During Testing



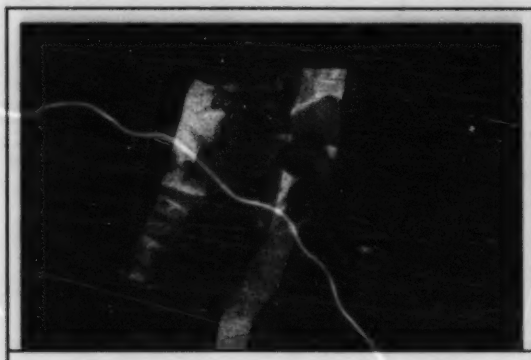
Modifications To M14 Shipping Plugs To Allow Fuze Function

Modifications To M14 Shipping Plugs To Allow Fuze Function

Modifications To M14 Shipping Plugs To Allow Fuze Function

Typical "Neutralized Mine" Results

Typical "Neutralized Mine" Results



Typical "Neutralized Mine" Results

Typical "Neutralized Mine" Results

Typical "Detonated Mine" Results

Typical "Detonated Mine" Results

CCMAY/TMAC/PROMAC BDM48 Unfuzed M14 Test Data

Annex C-1 to
BDM48 Test Thailand
Dated: May 01

	Setup				Results				
Trial #	DOB (mm)	Distance (m)	Operator	Environment	Time (min)	Functional Mine	Neutralized Mine	Destroyed By Detonator	Comments
2001-05-21-09	10	5	Tea	Low grass, "dry" soil			X	X	. Broken apart, fuze functioned (spring inverted) . Fuze and detonator both separated from main charge
2001-05-21-10	120	5	Pop	Low grass, "dry" soil	5		X	X	. Broken apart, fuze functioned (spring inverted) with firing pin torn out . Fuze and detonator both separated from main charge
2001-05-21-11	150	4.6	Tea	Low grass, "dry" soil	5		X	X	. Lower body intact, detonator still in mine body . Body in or close to original position . Fuze functioned (spring inverted). . Main charge "powdered" (from strong impact)
2001-05-21-12	120	5	Pop	Low grass, "dry" soil	6		X	X	. Body intact, cap removed . Body in or close to original location . Fuze functioned (spring inverted)
2001-05-21-13	120	5	Tea	Low grass, "dry" soil	4		X	X	. Broken apart . Fuze functioned (spring inverted) . Detonator and fuze both separated from main charge
2001-05-21-14	170	5	Pop	Low grass, "dry" soil	7		X	X	. Untouched, in spoil pulled back by blade . Fuze functioned.
2001-05-22-01	130	5	Pop	Low grass, "dry" soil, mine rolled with pressure plate facing teeth	4		X		. Broken apart . HE filler "powdered" . Fuze and detonator both separated from main charge . Spring damaged, firing pin removed, fuze state unconfirmed
2001-05-22-02	130	5	Pop	Low grass, "dry" soil, mine rolled with pressure plate facing teeth			X		. Broken apart . HE filler "powdered" . Fuze and detonator both separated from main charge
2001-05-22-03	200	5	Tea	Low grass, "dry" soil, mine rolled with pressure plate facing operator	4		X		. Broken apart . Fuze and detonator both separated from main charge . Spring not inverted (fuze not functioned)
2001-05-22-04	200	5	Tea	Low grass, "dry" soil, mine rolled with pressure plate facing operator	4		X		. Broken apart . Detonator separated from main charge . Fuze state unconfirmed
2001-05-22-05	80	5	Pop	Low grass, "dry" soil, mine rolled with pressure plate facing operator	5		X	X	. Broken apart . Fuze and detonator both separated from main charge . Spring inverted (fuze functioned)
2001-05-22-06	70	5	Pop	Low grass, "dry" soil, mine rolled with pressure plate facing operator			X		. Broken apart . Fuze and detonator both separated from main charge . Spring damaged (fuze state unconfirmed)
2001-05-22-07	70	5	Tea	Low grass, "dry" soil, mine rolled with pressure plate facing teeth	4		X	X	. Broken apart . Fuze separated from main charge . Detonator holder damaged, detonator not found . Spring inverted (fuze functioned)
2001-05-22-08	210	5	Tea	Low grass, "dry" soil, mine rolled with pressure plate facing teeth	6	X			. Intentionally buried deeper than BDM48 design depth . Mine untouched . Mine recovered for later reuse
2001-05-22-09	110	5	Pop	Heavy grass, "dry" soil			X		. Broken apart . Fuze and detonator both separated from main charge . Spring damaged (fuze state unconfirmed)
2001-05-22-10	90	5	Pop	Heavy grass, "dry" soil			X		. Broken apart . Fuze and detonator both separated from main charge . Spring damaged, firing pin gone (fuze state unconfirmed)
2001-05-22-11	160	5	Tea	Heavy grass, "dry" soil			X	X	. Broken apart . Fuze and detonator both separated from main charge . Piece of detonator holder found. . Spring inverted (fuze functioned)

2001-05-22-12	240	5	Tea	Heavy grass, "dry" soil			X		. Intentionally buried deeper than BDM48 design depth to see if grinding pressure would set off mine. Section commander gestured a deep burial to operator. . Broken apart . Fuze and detonator both separated from main charge. . Spring damaged, firing pin removed, (fuze state unconfirmed)
2001-05-22-13	140	4.7	Pop	Heavy grass, "dry" soil			X		. Broken apart . Fuze removed from main charge . Spring damaged, firing pin gone (fuze state unconfirmed)
2001-05-23-01	80	4.6	Pop	Wet, muddy soil (top 2cm), drier soil beneath, short grass	6			X	. Intact, in place, small gouge out of cap from tooth scrape . Fuze functioned (cap depressed) . Mine was in a low point created by a previous track groov bridging and may not have been able to dig to full depth at the mine location.
2001-05-23-02	140	5.4	Tea	Wet, muddy soil (top 2cm), drier soil beneath, short grass				X	. Intact, in place, no marks . Fuze functioned (cap depressed) . Mine was in a low point created by a previous track groov bridging and may not have been able to dig to full depth at the mine location.
2001-05-23-03	80	4.5	Pop	At base of small trees beside small mound, "dry" soil			X	X	. Broken apart . Fuze functioned (spring inverted) . Fuze removed from main charge
2001-05-23-04	90	6.4	Tea	Around roots of small (2m high) brush, "dry" soil				X	. Intact, 3 minor impact marks from teeth . Found in edge of processed area. . Likely caused by slow drum rotation moving mine around rather than breaking it apart.
2001-05-23-05	250	5.4	Pop	Low grass, "dry" soil		X			. Intentionally buried deeper than BDM48 design depth to see if machine pressure would activate mine fuze. No scraping after grinding. . First attempt only achieved 120mm depth. Second attempt only achieved 170mm. Drum rotation slowed and stalled frequently. . Operator complained of mud buildup slowing rotation speed. Could have been mud buildup around bearing ends. . Mine untouched and not functioned. Mine recovered for later reuse.
2001-05-23-06	70	5.2	Tea	Low grass, "dry" soil			X		. Broken apart . Fuze and detonator removed from main charge . Spring damaged (fuze state unconfirmed)

Definitions

1 Functional Mine
The mine is intact, substantially undamaged, and capable of functioning as designed.

2 Neutralized
The mine can no longer function as designed as the means of initiation have been removed.

3 Destroyed by Detonation
The mine has been detonated.

4 Dry vs Wet Soil
None of the soil was really dry. See the photos for comparative dry/wet evaluation.

5 DOB
Depth of Burial as measured from ground surface to top of mine. If mine has been rolled on its side, DOB is measured to the top-most part of the mine.

Notes

1 One unfuzed M14 was buried at 200mm and subsequently excavated by hand to ensure that the fuze was not being functioned during mine placement. On retrieval the M14 was untriggered, indicating that the burial technique was appropriate.

Summary

25 unfuzed M14 mine tests
2 tests at >200mm DOB (intentionally too deep) - mines remained functional
1 test at > 200mm DOB (intentionally too deep) - mine neutralized due to operator zeal
22 tests at 0mm<DOB>200mm, upright and rolled 2 directions

3 mines definitely detonated
1 mine definitely neutralized but not detonated
18 mines either detonated or neutralized (uncertain which)

CCMAT/TMAC/PROMAC BDM48 Live M14 Test Data

Annex D to
BDM48 Test Thailand
Dated: May 01

Trial #	Setup			Results				
	DOB (mm)	Operator	Environment	Time (min)	Functional Mine	Neutralized Mine	Destroyed By Detonation	Comments
2001-05-24-01	0	Tea	Low grass, "dry" soil, end of lane				X	. Detonation, no debris
2001-05-24-02	0	Tea	Low grass, "dry" soil, side of lane				X	. Detonation, no debris . Carbide top of one cone tooth found in debris. Tooth continued use for 4 more tests. . Damaged tooth was right near middle of drum indicating that drum was properly centred over mine when detonated.
2001-05-24-03	0	Tea	Low grass, "dry" soil, end of lane				X	. Detonation, no debris
2001-05-24-04	-6	Tea	Low grass, "dry" soil, side of lane, mine about 1/4" above ground level				X	. Detonation, no debris
2001-05-24-05	50	Pop	Low grass, "dry" soil, end of lane				X	. Detonation, no debris
2001-05-24-06	40	Pop	Low grass, "dry" soil, side of lane				X	. Detonation, no debris
2001-05-24-07	50	Pop	Low grass, "dry" soil, side of lane	2.5			X	. Detonation, no debris . Tooth damaged from trial 2001-05-24-02 replaced before this test.
2001-05-24-08	40	Pop	Low grass, "dry" soil, end of lane				X	. Detonation, no debris
2001-05-24-09	100	Pop	Low grass, "dry" soil, side of lane	2.5			X	. Detonation, no debris
2001-05-24-10	100	Pop	Low grass, "dry" soil, end of lane	3			X	. Detonation, no debris
2001-05-24-11	100	Tea	Low grass, "dry" soil, side of lane	3			X	. Detonation, no debris
2001-05-24-12	110	Tea	Low grass, "dry" soil, end of lane	2			X	. Detonation, no debris
2001-05-25-01	150	Pop	Low grass, "dry" soil, side of lane	1.5			X	. Detonation, no debris
2001-05-25-02	150	Pop	Low grass, "dry" soil, end of lane, beside large tree and root	5			X	. Detonation, no debris . Extra time required to dig out surrounding tree root.
2001-05-25-03	150	Tea	Low grass, "dry" soil, side of lane, around smaller roots	2			X	. Detonation, no debris
2001-05-25-04	150	Tea	Low grass, "dry" soil, end of lane	2			X	. Detonation, no debris . Another chipped tooth (carbide tip) noticed; not sure from which trial . Blast evidence (soot, dirt traces) show that most of mine detonations are occurring near the middle of the drum (as desired).
2001-05-25-05	0	Tea	Light brush, "dry" soil, side of lane	1			X	. Detonation, no debris . Short time possibly due to operator short-cutting the digging pattern and placing drum directly on mine. Need to reinforce digging pattern for trials even though it may not be needed in actual demining operations.
2001-05-25-06	0	Tea	Light brush, "dry" soil, end of lane	1			X	. Detonation, no debris . Short time possibly due to operator short-cutting the digging pattern and placing drum directly on mine. Need to reinforce digging pattern for trials even though it may not be needed in actual demining operations.
2001-05-28-01	0	Pop	Light brush, "dry" soil, side of lane, beside large tree	1			X	. Detonation, no debris
2001-05-28-02	30	Pop	Light brush, "dry" soil, end of lane, next to large lump of soil - would need to be removed first	3			X	. Detonation, no debris
2001-05-28-03	50	Pop	Light brush, "dry" soil, side of lane, beside large tree - no hinerance to BDM48 head but close to machine arm			X		. Pieces found in spoil, O ring found in soil stuck in machine head. . Spring found, inverted & chipped, firing pin gone. . Detonator untouched by firing pin, still in mine body. . HE gone/powdered (fragments found in soil). . Detonator found by digging - too much metal in ground to be able to use metal detector effectively.
2001-05-28-04	50	Tea	Light brush, "dry" soil, end of lane				X	. Detonation, no debris
2001-05-28-05	100	Tea	Light brush, "dry" soil	2			X	. Detonation, no debris
2001-05-28-06	90	Tea	Light brush, "dry" soil, end of lane	1.5			X	. Detonation, no debris
2001-05-28-07	100	Pop	Light brush, "dry" soil, side of lane	2.5			X	. Detonation, no debris
2001-05-28-08	150	Pop	Light brush, "dry" soil, end of lane	2.5			X	. Detonation, no debris
2001-05-28-09	170	Pop	Light brush, "dry" soil, side of lane	3.5			X	. Detonation, no debris

2001-05-28-10	150	Tee	Light brush, "dry" soil, end of lane	2			X	. Detonation, no debris
2001-05-28-11	200	Tee	Low grass, "dry" soil, end of lane	2			X	. Detonation, no debris
2001-05-28-12	200	Tee	Low grass, very wet, muddy soil, side of lane	2.5			X	. Detonation, no debris
2001-05-29-01	200	Pop	Low grass, "dry" soil, end of lane	3			X	. Detonation, no debris
2001-05-29-02	200	Pop	Light brush, "dry" soil, side of lane	2.5			X	. Detonation, no debris
2001-05-29-03	100	Pop	Low grass, "dry" soil, end of lane, pressure plate rolled toward teeth	1			X	. Detonation, no debris
2001-05-29-04	100	Tee	Low grass, "dry" soil, end of lane, pressure plate rolled toward operator		X			. Mine found intact and unfired, under large amount of soil in berm. . Slight damage to bottom edge of mine. . Found by digging - too much metal in ground to be able to use metal detector effectively.
2001-05-29-05	50	Tee	Low grass, "dry" soil, end of lane	1			X	. Detonation, no debris

Definitions

1 Functional Mine
The mine is intact, substantially undamaged, and capable of functioning as designed.
2 Neutralized
The mine can no longer function as designed as the means of initiation have been removed.
3 Destroyed by Detonation
The mine has been detonated.
4 Dry vs Wet Soil
None of the soil was really dry. See the photos for comparative dry/wet evaluation.
5 DOB
Depth of Burial as measured from ground surface to top of mine. If mine has been rolled on its side, DOB is measured to the top-most part of the mine.
6 Time is from start of digging to detonation (compared with total digging and scraping time in MRM and unfuzed M14 tests).

Notes

1 For safety, no soil was placed on top of live M14 mines. This makes it more difficult for the machine to detonate the mine since there is no soil "plug" to push down on the mine unless the machine first displaces soil into the hole.
2 Prior to live M14 tests, 4 live M14 mines were pressed using the outer shoe or "nose blade" of the BDM48. This was largely a confidence builder to demonstrate the M14 effects to the operator.
3 Digging pattern used in trials allows a small pile of spoil to develop to help catch broken M14 pieces for analysis. May not be needed in demining operations but for testing it keeps the drill consistent, avoids changes in procedures that MIGHT compromise results, and minimizes scatter of pieces. With successfully detonated mines it does not matter, but it might matter if a mine does not detonate.

Summary

35 Live M14 mine trials
Low grass and light brush environments
DOB: 0, 5, 10, 15, 20 cm
33 Detonated mines
1 Neutralized mine
1 Functional, live mine

M14 TEST PROCEEDURE

1. Mine Details:

   a. One case of ninety M14 mines and detonators were provided by the Royal Thai Army for the purposes of evaluating the BDM48.

   b. M14 Stock number: 1345-096-3093-K121 Mine Anti-personnel non-metalic M14 with integral fuze.

   c. Lot number: LOP-32-22

   d. Date of manufacture: Jan 1956

2. Mine Storage and Handling.

   a. All mines were stored by TMAC under the supervision of a Royal Thai Army Officer. Initial inspection indicated that all mines and detonators and packaging were in a serviceable condition with no visible signs of deterioration. Mines and detonators were received at the beginning of each workday. A Royal Thai Army Officer kept a log of all mines and detonators that the assessment team used.

   b. Upon receipt of the mines from TMAC all mine bodies were spray painted bright red to assist in the recover of component pieces.

   c. Detonators were always kept separate from the mines and were only inserted into the mine body immediately before use during testing.

   d. Unused mines, detonators, and broken mine bodies were returned to TMAC at the end of each workday.

3. Safety and Training for Deminers.

   a. TMAC deminers were provided to recover pieces of broken mines during the live trials. Therefore CCMAT provided a training session for the TMAC deminers to familiarize them with the mine components and their function should they have to recover a broken mine after a test. Emphasis was place on the main filling (29 grams tetryl), and detonator.

b. TMAC deminers use a Vallon mine detector for demining. Therefore should a mine fail to function and be broken up during a test the Vallon detector would be used to recover the detonator. It was established through testing that the Vallon detector could reliably detect the M14 fuze to a depth of seven centimetres in the soil types present on the test site.

c. TMAC demining SOPs dictate that demining teams are spaced 25 meters or more apart while they are working. This factor was taken into account during the live trial planning where the trial team intended to conduct trials in more than one lane at a time, and the possibility existed that deminers might have to recover mine components and detonators in several lanes concurrently.

d. The potential threat of a 29-gram detonation existed during the live mine trials. That detonation would be contained within in the steel body of the BDM48 working head. When conducting live trials all personnel were removed to a firing point located 90 meters from the test site, all personnel wore protective body armour when observing the trials and when clearing the site after the trials.

4. Trial Procedure

a. The Vallon metal detector was used to ensure the exact location where the mine was buried was free of mines then the hole for the M14 mine was prepared.

b. The BDM48 system was manoeuvred into place with the door to the cab closed.

c. The detonator was inspected along with the detonation chamber in the mine. The detonator was inserted immediately prior to laying the mine.

d. All personnel except the person laying the mine departed the area.

e. The mine was armed by turning the pressure plate and removing the safety clip.

f. The mine was placed in a prepared spot with extreme caution as it could function with as little as 9 Kg of pressure on the pressure plate.

g. As a safety precaution live mines were not covered with dirt during any trial. This mitigated the potential of causing the mine to detonate while covering the mines.

h. Reference marks were painted on the ground just before the mine was placed to locate the original position of the mine after the soil was worked by the BDM48 system.

i. Once all members of the assessment team were recovered to the firing point the BDM 48 operator was contacted by radio to start the test.

5. Clearing the area.

a. The BDM48 operator signalled that he had finished processing the area by sounding the horn, he remained inside the cab until an explosive specialist cleared the area.

b. An explosives specialist cleared the area when a detonation occurred by visually checking for pieces of the main charge and looking into the BDM48 excavation for other debris that might have impacted the test.

c. An explosives specialist cleared the area when no detonation occurred by:

(1) Looking for evidence of the mine body and components.

(2) By using the reference marks, checking the original position of the mine with the Vallon mine detector. If metal was detected then the location was manually demined.

(3) Soil removed by the BDM48 was checked with the Vallon metal detector. If metal was found then standard demining procedures were used to remove what was found. If there was no response by the mine detector then a 7-centimetre layer (the width of the deminers trowel) was removed and the process was repeated until all the soil was cleared.

(4) Once all the mine parts were recovered and the detonator recovered then the area was declared cleared.

MRM/M14 CORRELATION

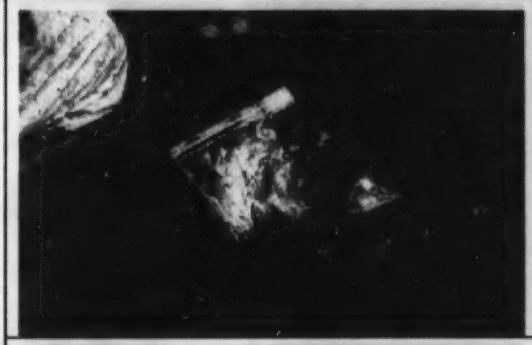
1. To determine whether the MRMs provide data that is representative of real mines one would normally look at whether the MRMs provide similar rates of neutralization, detonation, and targets remaining functional. This is shown below, but it is not a particularly helpful comparison in the case of a "destructive" machine like the BDM48.

Table 1: Percentage Comparisons

Target Type	Functional	Neutralized	Detonated	"Dead" (Neutralized or Detonated)
Type 72A MRM	6	86	8	94
Unfuzed M14	0	86	14	100
Live M14	3	3	94	97

2. While the percentage of targets left functional or "live" is probably useful, the questions neutralized/detonated values are misleading. There is almost no way to be sure whether an MRM has been detonated before being broken apart or broken apart before being detonated. In many cases, it is unclear whether the MRM has been detonated at all. In live mine trials this question became immediately clear. Interestingly however, the unfuzed M14 trials revealed the same results as the MRMs. The MRMs might not have this problem with a "non-destructive" machine.

3. Perhaps a more relevant comparison for a machine like the BDM48 would be to examine the fragments of both the MRMs and the M14 mines. The images that follow suggest that even though the MRM is a Type 72A and the real mine an M14, there is a great similarity in exactly how the targets are behave and are neutralized. Further, there has been the legitimate criticism that the plastic chosen for the MRMs may not correspond exactly to the real mine and that therefore the manner in which the MRM breaks up may not truly represent a real mine. The images appear to set this fear to rest, at least as far as this pair of MRM and mine is concerned. The images are not meant to be a one-to-one comparison.

MRM Fragments	M14 Fragments
	

MRM Fragments	M14 Fragments

BRUSH CUTTING

1. During the training, MRM and unfuzed M14 trials there were several occasions during which brush cutting was demonstrated. The BDM48 encountered no difficulty whatsoever with any of the vegetation it encountered including bamboo. The system was used to debrush areas containing knee-high grass as well as 6-meter tall bamboo clusters. In addition to the basic brush cutting, the BDM48 system's articulated joints allowed the cutting to follow terrain contours very easily, although some operator experience and practice are necessary for this.

2. Attempting to establish rates of brush cutting is complicated. The variables that impact rates of brush clearance include: operator skill and experience, the type and size of vegetation, the features of the underlying terrain, the need (or lack of need) to avoid disturbing the ground, or how close to the ground the vegetation needs to be cut, as well as the machines cyclical output. Without large sections of uniform terrain and vegetation cover, there is no practical way to establish representative brush clearance rates.

3. While the data should not be extended too far, five separate debrushing experiments were conducted in which "before" and "after" images were taken, the area cleared was approximated and the time taken recorded. Clearly, there is a great dependency on the variables listed above, but the exercise does give a general idea of the BDM48's potential debrushing rates. Table 1 below should be viewed together with the photographs shown in the figures that follow.

Table 1: Sample Debrushing Rates

Area #	Vegetation Type	Terrain Type	Area Debrushed (sq. m.)	Time Taken (min.)	Debrushing Rate (sq.m./min.)
1	Bamboo and other trees	Termite Hill	23	3	7.5
2	Bamboo and other trees	Termite Hill	42	6	7
3	Bamboo and other trees	Termite Hill	34	9	4
4	Bamboo and other trees	Flat	40	7	5.5
5	Bamboo and other trees	Flat	55	7	8

Brush Clearing
Area 1 - Before

Brush Clearing
Area 1 - After

Brush Clearing
Area 2 - Before

Brush Clearing
Area 2 - After

Brush Clearing
Area 3 - Before

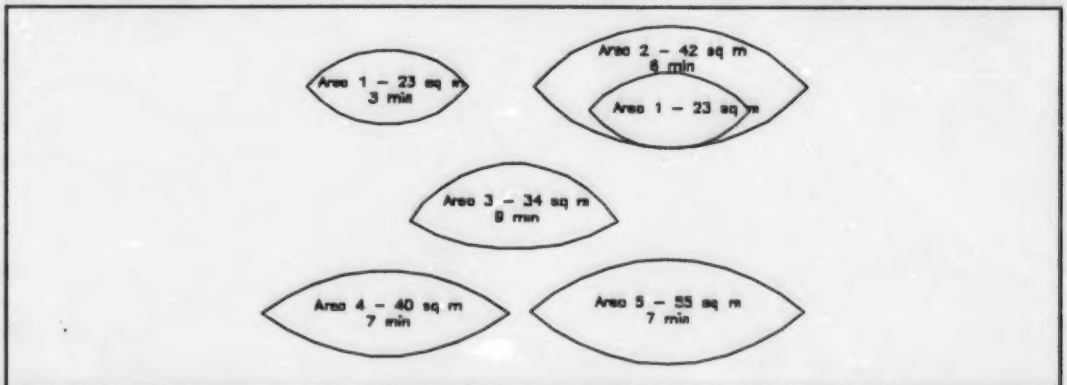
Brush Clearing
Area 3 - After

Brush Clearing
Area 4 - Before

Brush Clearing
Area 4 - After

Brush Clearing
Area 5 - Before

Brush Clearing
Area 5 - After



Brush Clearing Rates

Annex H to
BDM48 Test Thailand
Dated: May 01

STANDARD OPERATING PROCEEDURES

MECHANICAL ASSISTANCE TO DEMINING

PROMAC BRUSH DEMINER 48 (BDM48)

DRAFT

Copy Number	
Held By	
Date of Issue	

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REVISION LIST

Revision Number	Date	Description	Signature
00	Mar 01	Original Issue	

1.0 INTRODUCTION

1.1 The Thailand Mine Action Center (TMAC) considers mechanical assistance to demining as an essential element of its humanitarian demining program. The reason for using mechanical systems is to accelerate manual demining or demining with dogs. Therefore the BDM48 will not be used as a stand-alone system. This document establishes the Standard Operating Procedures (SOP) for using the PROMAC BDM48 as mechanical aid to Humanitarian Demining. These SOPs will be amended as experience is gained with operating the BMD48. The BDM48 provides the following general capabilities:

1.1.1 Safety and security for the operator by working from the cleared area and reaching into the mined area.

1.1.2 Removes vegetation to make the ground available for using mine detectors or mine detecting dogs.

1.1.3 Removes the tripwire threat.

1.1.4 Removes or reduces the mine threat by neutralizing mines by grinding or destroying mines by detonation.

1.1.5 Contours the ground.

1.1.6 Works in and around obstacles to demining including termite hills, slope up to 45 degrees.

1.1.7 Applies the BDM48 tool head above and below the level of the machine

1.1.8 Works through root structure, and rough ground.

1.1.9 Works in adverse weather conditions such as rain and saturated soil.

1.1.10 Provides the demining unit with a finesse tool that can work around specific locations without destroying infrastructure and vegetation that locals want to save.

1.2 Concept of employment.

1.2.1 The BDM 48 system will fit into TMAC's current command and control structure and integrated into TMAC's process of mine clearing which includes all levels of survey, mined area marking, demining, and post demining action. The system will be employed as part of a mechanical demining platoon. The mechanical demining platoon will be controlled centrally by TMAC's Humanitarian Mine Action Units (HMAU) plans staff who selects and controls the locations and priorities of work where the platoon will work.

1.2.2 Role 1: Brush clearing and demining.

1.2.3 Role 2: Area reduction.

1.2.4 Role 3: Quality assurance.

1.3 Limits of employment.

1.3.1 Areas containing loose wire or concertina. These obstacles wrap themselves around the arbor and eventually stop the working tool.

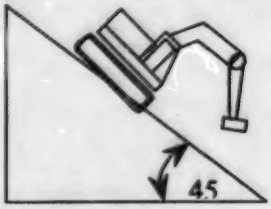
1.3.2 Reduced visibility. The operator must have a clear view of the machine head and the target area. The machine should not be used at night or in periods of heavy fog or rain.

1.3.3 Supersaturated soil. The BDM48 tool will achieve the intended effect of grinding mine when soil is saturated. However the prime mover should not be trafficked through ponding water or over spongy ground to avid bogging down the prime mover.

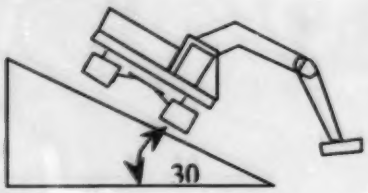
1.3.4 Fording. The prime mover can walk through water up to the level of the tacks. As a preventative maintenance measure after fording the final drives are to be drained and refilled (8 liters of oil per side).

1.3.5 Slope.

1.3.5.1 With the tracks pointed down hill the prime mover can comfortably work on a 45 degree slope without tipping the machine or slipping.



1.3.5.2 With the tracks pointed across the slope the machine can comfortably work on a 30 degree slop without tipping the machine or slipping.



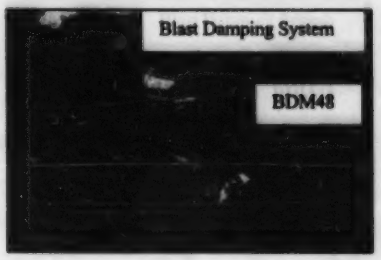
2.0 GENERAL INFORMATION ON THE BDM48 SYSTEM

2.1 The BDM48 system is based on a case 9040B tracked excavator with a protection package for the operator and arm, a blast damping system to protect the excavator arm during a mine blast, quick relief valves on the hydraulic system to avoid hydraulic damage during a large blast, and finally a purpose built end effecter called the BDM48. The system was fully tested by the Canadian Center for Mine Action Technologies for its ability to effectively grind mines as well as its performance in the blast environment. The full reports are listed as references A and B at the end of this SOP.

2.2 Description of Components.

2.2.1 Prime Mover: The prime mover for the system is a CASE 9040B. See annex C for the full technical detail. The prime mover has a purpose built cab designed to withstand the blast effect of AT mines as well as ordnance up to 105mm artillery rounds.

2.2.2 Blast Damping System. This system prevents the transfers of force into the arm of the prime mover during the blast of mines containing an explosive filler up to 7 kilograms.



2.2.3 BDM 48 End Effecter. This is a sacrificial grinding system that removes brush and bamboo as well as grind AP mines to a depth of 20 centimetres.

2.3 System Dimensions.

2.3.1 Overall Height: 3.22 meters

2.3.2 Overall Length: 10.1 meters

2.3.3 Overall Width: 5.1 meters

2.3.4 Ground Clearance: 0.76 meters

2.3.5 Maximum Reach Radius at Ground Level: 9.0 meters.

2.3.6 BDM 48 Dimensions: The BDM 48 when pushed into the ground will grind a bite 0.30 meters wide by 1.2 meters long x 0.20 meters deep.

2.3.7 System Operating weight: 24,200 kilograms.

2.4 Rates of Clearance and Speed.

2.4.1 Speed over the ground: 5 kilometers per hour.

2.4.2 Rate of Grinding Soil

2.4.3 Grinding a bite: 1.0 minute

2.4.4 Grinding a spot: 5-8 minutes

2.4.5 Grinding a 6 x 26 meter QA spot: 156-189 minutes.

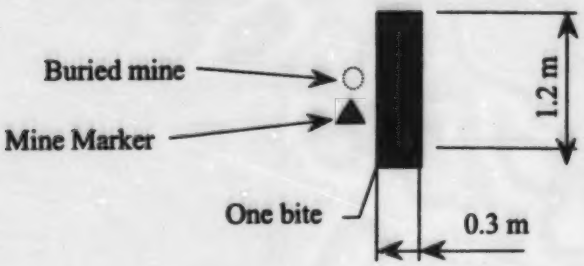
2.4.6 Rate of Clearing Bamboo: one stand in 10 minutes.

2.4.7 Rate of Clearing Underbrush: 2-3 meter high, 4-8 square meters per minute.

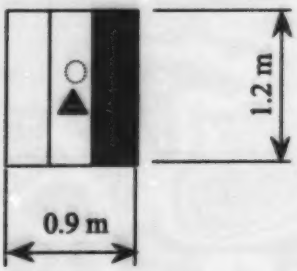
3.0 DRILLS

3.1 Mine Marking. As mines are found they are marked using the normal TMAC procedure of placing a red triangle placed one hand width back from the suspected location.

3.2 Mine Grinding. When the operator pushes the BDM 48 into the ground this is said to take one-bite as shown below. The operator moves the BDM 48 about one tool width to the right of the marked location and then pushes the BDM 48 into the ground to take the first bite as shown below. A total of three bites are applied to every marked location from right to left as shown below to ensure the marked area is completely ground. It is done in order from right to left in order to build up some spoil under the BDM48 arbor which will help contain mine pieces under the BDM 48 head should the mine not detonate.



3.2.1 A total of three bites are applied to every marked location from right to left as shown below to ensure the marked area is completely ground. It is done in order from right to left in order to build up some spoil under the BDM48 arbor which will help contain mine pieces under the BDM 48 head should the mine not detonate.

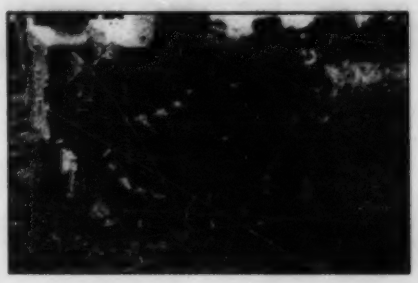


Scraping with
Idler End Blade

3.2.2 The operator then uses the blade located on the idler end BDM 48 to scrape the spoil from the excavation so that the section commander can observe the depth of cut and check the bottom of the excavation.

3.2.3 Completing the grinding task. If at any time the operator sees the mine then he is to identify it from within the cab of the machine then report what he sees to the section commander. After identifying the mine he is to directly attack the mine with the BDM 48 to grind it in place.

3.2.4 At the end of the working day the operators mush remove any spoil from inside the head of the machine and check the machine for mine components.



3.2.5 At the end of the working day the TMAC site commander shall ensure all mines or mine parts are destroyed in accordance with SOP XXX.

3.2.6 It is normal for the section commander and operator study the marked spot to determine slope and obstacles that might impact the application of the tool head. A plan is then made to determine what has to be done to allow the operator to apply the head in the standard grinding pattern.

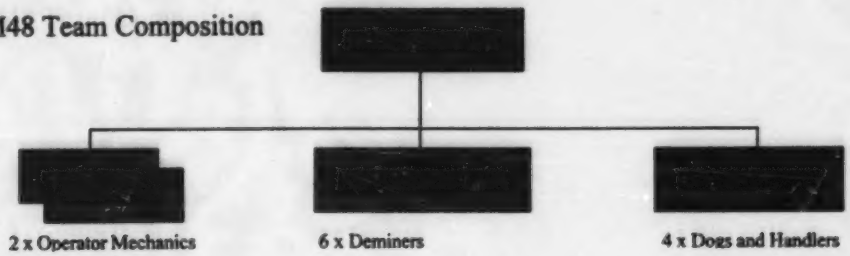
3.3 Clearing the excavation.

3.3.1 If no detonation is heard then the operator notifies the section commander that he is finished by sounding the horn on the machine. The section commander then visually checks the excavation for depth and broken mine parts. The section commandar then moves a demining team into place to manually demine the berm.

3.3.2 The aim of manually demining the berm is to recover the detonator, fuse mechanism and as many mine parts as possible to prove the mine has been neutralized. This is done by using standard demining procedures as seen in SOP XXX and carefully excavating one trowel width at a time until all the spoil has been inspected.

3.3.3 Normally neutralized mines are broken into many pieces, the firing mechanism has been removed from the detonator and the filler has been removed from the mine. The filler is normally pulverized and is unable to be recovered. The mine body is shattered so that only ½ - 2/3 of the pieces can be recovered.

3.3.4 M48 Team Composition



3.4 Debrushing.

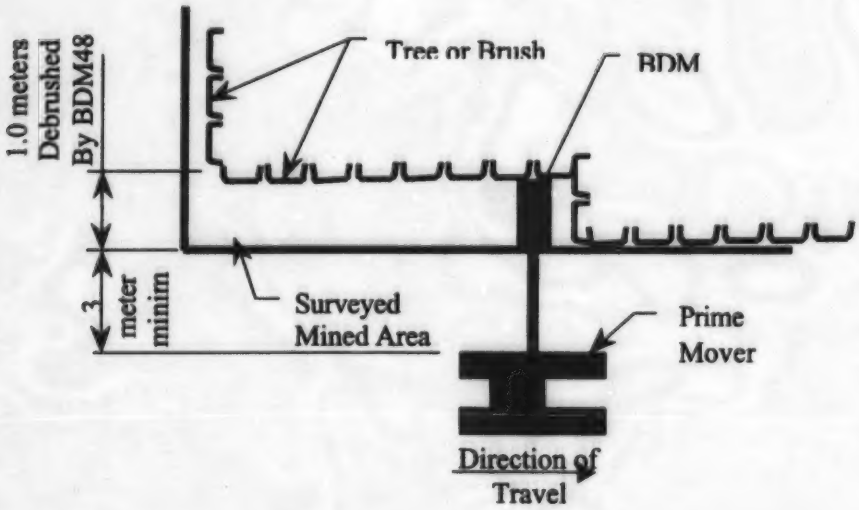
3.4.1 The BDM48 system always works from the cleared area.

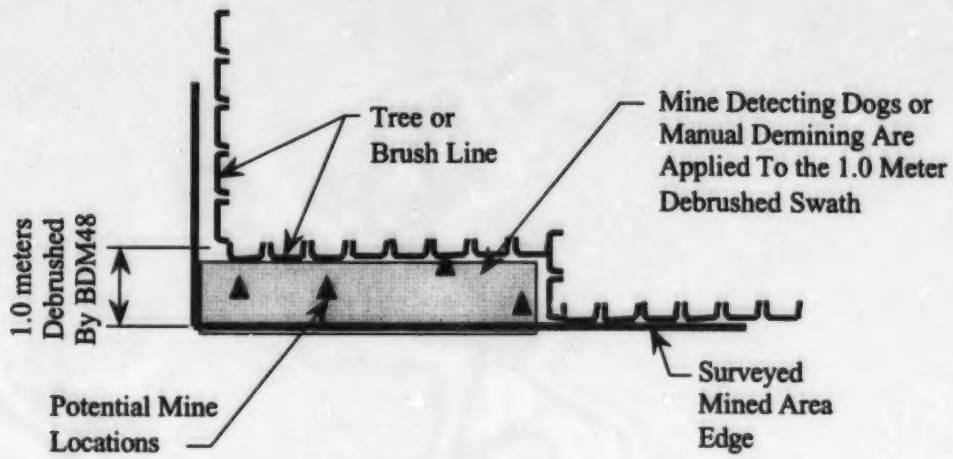
3.4.2 Start work by positioning the Prime mover so that the grinding head is suspended straight down over the edge of the marked edge of the mined area. Positioning the prime mover in this manner ensures that the prime mover will be at least three-meters from the working head at all times.

3.4.3 Raise the BDM 48 to the top of the brush or bamboo, allow the arbor to reach its maximum speed then move the tool through the brush from side to side removing one head-width at a time. Starting at the bottom of the brush or bamboo causes the brush to topple over making it difficult for the operator to grind the brush into pieces small enough for the deminers to work in.

3.4.4 Debrush a 1-3 meter swath as per the section commanders direction.

3.4.5 Brush clipping accumulation should be left in the mined area until it is checked by manual demining methods or mine detecting dogs. Then brush accumulation can be removed by the Pearson Tractor and burned.





3.4.6 Spot Clearance using the BDM 48. The Operator and section commandar should inspect the marked location to look for signs of the mine on the surface, direction of slope, and obstacles that the cutting head will encounter.

3.4.7 Detections Located on the edge of underbrush. The suspected mine is marked as per normal TMAC marking procedures. The BDM 48 is pushed into the brush and the normal three-spot grinding procedure is followed.

3.4.8 Transition Zones. A transition zone occurs at the junction where the ground abruptly changes elevation or has hollows. The BDM 48 system is flexible enough to be maneuvered into any transition zone. For concave transition zones the BDM 48 should be applied from the top to the bottom of the area to be ground then scraped from top to bottom. For convex transition zones the normal drill is used.

3.4.9 Rock. Using the BDM 48 against bed rock or boulders will break off the teeth.

4.0 SAFETY AND SAFETY DISTANCES

4.1 Machines should work no closer than 25 meters from each other.

4.2 Operators should wear ear defenders at all times.

4.3 While operating the machine the door shall be kept closed.

4.4 Manual deminers and demining dogs should work no closer than 250 meters from the BDM48 system.

4.5 When working in areas where antitank mines are prevelant people should work no closer than 250 meters from the machine.

Annex I to
BDM48 Test Thailand
Dated: May 01

BDM 48 SYSTEM MODIFICATIONS

1. **Idler End Blade**. In the original DRES trials the BDM 48 was used to sweep away the ground up soil to prove the depth of cut and aid with collecting the broken Mechanical Reproduction Mine test pieces. During the Thailand trials this same method of removing the ground soil was used. But because the BDM 48 trials were conducted at the beginning of the South East Asia wet season the daily monsoon rains quickly supersaturated the soil. Using the blade to clear the spoil from the ground up area overloaded the flexible shock coupling. Additionally, the high clay content caused the soil to ball up while the machine was sweeping. It should be noted that sweeping heavy materiel sideways using the excavator boom is contrary to established excavator operating procedures. While sweeping dry, light materiel was not a problem in the DRES trials the conditions in Thailand caused the assessment team to change the direction of materiel flow so that normal machine functions could be used. So to enable the operator to pull materiel towards the cab rather than sweep PROMAC installed an Idler End Blade as shown below. This also suited demining procedures for working in mined areas.

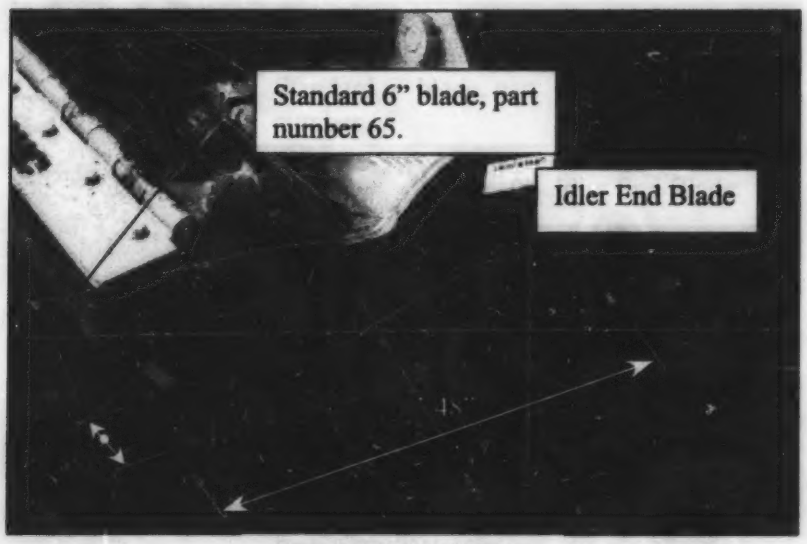


Figure 1: BDM 48 Modifications

Figure 2: Sweep Direction

2. **Side Blade Modification**. The side blade cutting edge width was reduced from and 10" blade to a standard six-inch blade to reduce the load on the shock coupling and reduce the amount of materiel that would ball up and compress during the scraping process. Refer to PROMAC item number 65 on the parts assembly drawing.

3. **Tool System Hydraulic Pressure Gage**. During the training process the operators could not sense the speed reduction of the BDM48 arbour causing the grinding drum to stop in the wet soil. This occurred because of a lack of operator experience with the kind of prime mover provided for the trial. A pressure gage was plumed into the cutting head pressure system to enable the operator to read the BDM48 hydraulic pressure at any one time. Therefore as the effort to cut in the muddy conditions increased the operator could monitor the corresponding increase in pressure to do the work. When the operator saw the pressure gage go above 310 bar he knew that the head was loaded too much and that he should raise the head out of the soil to allow arbour speed recovery. This is done to maintain the arbour speed and torque required to destroy landmines.

FUTURE MODIFICATIONS

4. When using the BDM48 in wet conditions soil would build up between arbour and the end plates as well as under the deck behind the cutting head. To reduce friction between the end plate and drum as well as reduce the possibility of mine parts becoming trapped in the cutter head these holding areas should be reduced as much as possible.

5. Shock Absorber Lateral Support. The BDM48 system has a shock absorber located between the cutting head and the boom that suspends the cutting head during use. When a blast occurs under the BDM48 the rubber suspenders in the shock absorber enables the entire tool assembly to travel up to 9 inches in the vertical plane thus reducing the load transferred into the boom and the hydraulic cylinders. Using the BDM48 to sweep away ground soil creates lateral loads that overstress the rubber suspenders inside

the shock absorber and could cause it to fail after prolonged use. Additionally the lack of lateral support allows the tool assembly to move too much making it difficult to control the sweeping action. It is recommended that future systems provide lateral stiffening while maintaining the designed vertical travel of the component.

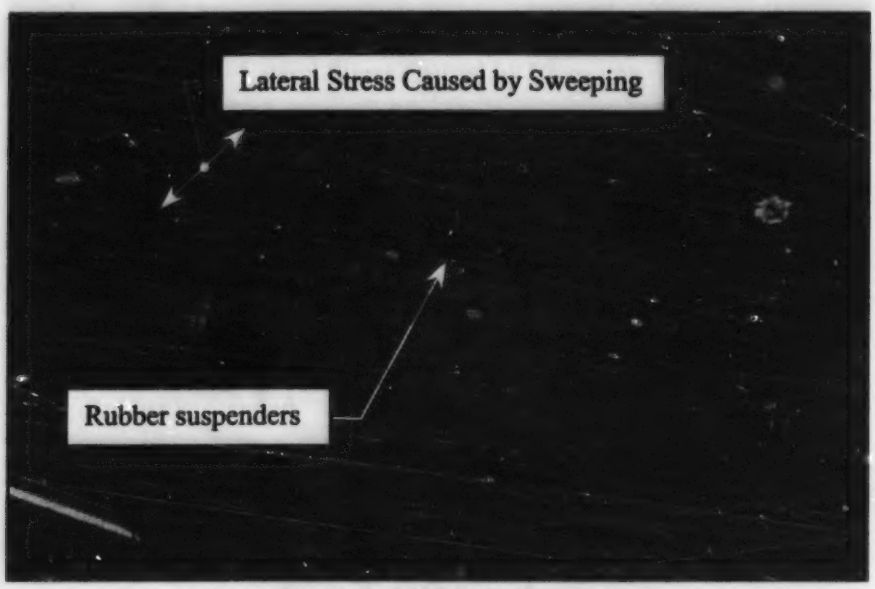


Figure 3: Shock Absorber Modifications

Comments on Promac

1st HMAU, TMAC Thailand.

The machine had been trial in Thailand for about 1 month in Nong yakaew village, Sakaeo province.

Nong yakaew is a self-defence village that locates along Thai-Cambodian border. This village was built on the area that once used for battling areas in Cambodian conflict. 1st HMAU is the first Thais mine action unit that deploys to overcome mine problem in Sakaeo province and pinpoint this village not only as the first priority but the operation base.

According to time consumption for civilian deminers creation to reinforces the operation and the typical rainy season that last about 4-5 months a year in the area, unit need to have a unique capability on solving small dangerous areas those spread over whole borders area mainly on higher ground while main function have to pause until next dry season coming. This option will assist the relief of tensions in some source. Such capability needs to have combinations of sections of deminers, dog teams and mechanicals.

Spot tasks in Sakaeo province was counted to 42 areas. Sized from a sq.m. to 100 sq.m.. Some of them are easily to operate and some of them are even easy to put up mine sign. The fastest and safest way to deal with this type of area is Promac.

Now 1st HMAU have received three kind of mechanics: Tempest, SDTT and Promac. Each machine has it's own character. Tempest is good at cut light vegetation. SDTT is good at reduce dangerous area. In order to deal with dangerous spot(not big), Promac is fit for that. Heavy vegetation such as tree or thick bushes or stumps are out of reach for the first two machine but for Promac they are looked ease.

There are certain area those skipped by Tempest and SDTT, termite hill, spaces between tree's root, road shoulder, ditches, area's corner etc.. Normally, dogs and deminers will be assigned to do the jobs. But one can tell that this type of operation will lasted them months and delay whole platoon down. From 1st HMAU perspective, Promac is fit for assist brush cutter such as Tempest and others which are deploy all over the world.

The track expand of Promac might sorts the soft ground constraint for other machines which haven't been compare with Tempest and SDTT in Thailand yet. The reach of Promac's boom will give the platoon distances from spot and let observer a chance to open up part of suspected area that cover by thick bush. Slope also obstructs the

operation even manual deminers the most reliable means of demining but not to Promac.

Because of it size and its clumsy movement each move have to be well planed .Low bed vehicle may need to assist for long distance transportation which not difficult to find in areas. The grinder head is not design for cut light vegetation such as grass.

Sincerely yours
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